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Field-Orientation-Dependent Magnetic Phases in $GdRu_2Si_2$ Probed with Muon-Spin Spectroscopy

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Centrosymmetric $GdRu_2Si_2$ exhibits a variety of multi-Q magnetic states as a function of temperature and applied magnetic field, including a square skyrmion-lattice phase. The material's behaviour is strongly dependent on the direction of the applied field, with different phase diagrams resulting for fields applied parallel or perpendicular to the crystallographic c axis. Using transverse-field μSR with fields applied along either the [001] or [100] crystallographic directions, we distinguish between the magnetic phases in this system via their distinct muon response, providing additional evidence for the skyrmion and meron-lattice phases, while also suggesting the existence of RKKY-driven muon hyperfine coupling. Zero-field μSR provides clear evidence for a transition between two distinct magnetically ordered phases at 39 K [1].

We will also discuss novel techniques related to the computation of muon stopping sites using density functional theory (DFT), that were crucial to our analysis in this study. Notably, by considering the energy barriers for moving between muon sites, and accounting for the zero-point energy of the muon, we were able to determine that there is only a single stable crystallographically distinct site. This muon site was confirmed experimentally, using angle-dependent measurements of the muon Knight shift.

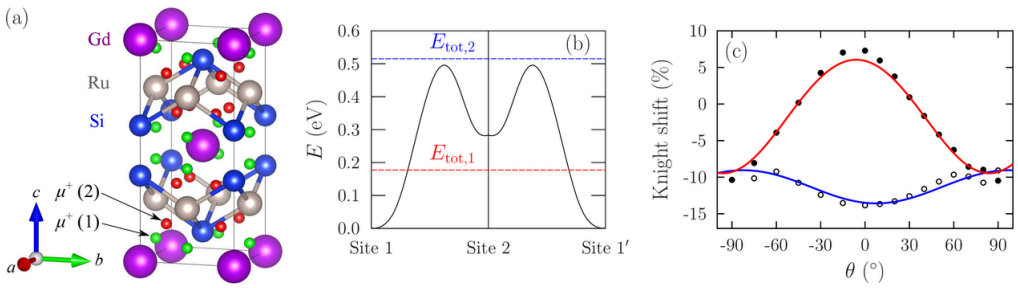

Figure 1: Muon sites in $GdRu_2Si_2$.

1. B.M. Huddart et al., Phys. Rev. B 111, 054440 (2025).

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